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has made cadastral or estate survey on a minute scale, with all the exactness of geodesy. If the country of the West had been triangulated, even grossly, and the land survey made upon that basis, its work would have been much more reliable and permanent. The topographic and even the geodetic surveys of France and England preceded the cadastral, or estate, surveys of that country, so that all boundaries are exact, and all features permanently located. These maps need to be changed only as the cultural features change.

There is in Europe an international geodetic system which is uniform and mutually dependent. In this country there should be such an interstate system, and this we have in the topographic and geological survey of the General Government. Upon this or an accurate scientific basis it is intended that the States shall have their surveys, and elaborate the details as much as desired.

In view of these imperfectly presented facts, then, the final consideration is, what should the State of Kansas do to secure the best benefits from the United States survey within her borders? The reply is, briefly, that the Legislature should make an appropriation for the enlargement of the scale of the maps, in order that more details may be shown and the maps be made more generally useful for all scientific and economic purposes. Other States are now doing this, and having the Government survey do the work for them, for the reasons — to briefly recapitulate — that the survey is already organized and equipped, and has the best specialists in its permanent employ, and the work can be done with infinitely greater accuracy than by hastily-organized State surveys with political hindrances, and they can do the work much cheaper for the States than they can do it themselves, and will conduct the work with the uniform system of the whole country. The cost to the State of Kansas for the enlargement of the map would be from $10 to $15 per square mile for all the survey work. Not being mountainous, the expenses would be light, and the progress more rapid. Already the eastern third of the State is surveyed by the topographical corps on the Government scale of four miles to the inch, and if we wait until the entire State is covered the cost of resurveying for the large scale of one mile to the inch will be much greater. The smaller scale is all needed to base boundary surveys upon, which will in time save much trouble.

The State work of the national survey should be managed by a commission of scientific men, who would have cognizance and control of the work which the Director of the United States would execute for them. Such a commission as the President of the Kansas Academy of Science, the Secretary of the State Board of Agriculture, and the Superintendent of Mines, would be appropriate and capable.

The Academy should appoint a committee to take the matter under advisement, to correspond with the Directors of the United States Geological Survey as to methods of procedure for coöperation, and get it into shape to present to the Legislature. The Academy should further memorialize the Legislature to act promptly in the matter, for the workmen are upon our ground, and the opportunity is passing.

ON THE DESTRUCTION OF THE PASSIVITY OF IRON IN NITRIC ACID BY MAGNETIZATION.

BY EDWARD L. NICHOLS AND W. S. FRANKLIN,
Of the University of Kansas.

I.

During the winter of 1884-5, the authors of this paper were engaged in the investigation of chemical behavior of iron in the magnetic field. In the course of their experiments they had occasion to bring into the field of a small electro-magnet, a beaker containing powdered iron submerged in cold concentrated nitric acid, the iron being in the passive state. While in the magnetic field the iron was touched with the bulb of a thermometer used in the determination of the temperature of the solution. Thereupon it lost its passivity, and the solution burst into violent effervescence. The reaction continued until the beaker was removed from the field, when the iron again became passive. Investigation showed that this change of condition was due to the action of the magnet, occurring instantly in solutions of high temperature or of small degrees of concentration, and taking place upon stirring within the field, even in the case of iron in cold concentrated acid. Mention of this fact has been made in the published account of the above-mentioned experiments.[1]

The further study of the phenomenon forms the subject of the present paper.

The influence of the electric current upon the passivity of iron has been known for half a century; Schönbein having described it in a letter to Faraday, in which the discovery of the passive state was first announced, as follows:

> " . . . I was very curious to know in what manner iron would be acted upon by nitric acid when used as an electrode. For this purpose I made use of that form of the pile known as the *couronne des tasses*, consisting of fifteen pairs of zinc and copper. A platina wire was connected with (what we call) the negative pole of the pile, an iron wire with the positive pole. The free end of the platina wire was first plunged into nitric acid, sp. gr. 1.35, and by the free end of the iron wire the circuit closed. Under these circumstances the iron was not in the least affected by the acid; and it remained indifferent to the fluid not only as long as the current was passing through it, but even after it had ceased to perform the function of a positive electrode. The iron wire proved, in fact, to be possessed of all the properties of what we have called a passive one. If such a wire is made to touch the negative electrode, it instantly becomes active, and a nitrate of iron is formed; whether separate from the positive pole or still connected with it, and whether the acid be weak or strong." [2]

Faraday[3], as is well known, followed up Schönbein's work with a variety of ingenious experiments of his own, and reached the conclusion that the passive state is due to the formation of an insoluble film of oxide upon the metal, and that the power of the electric current to produce passivity in iron which acts as a positive electrode, lies in the liberation of free oxygen at the surface of the metal. If Faraday's theory needed other confirmation than that afforded by his own varied experiments and those of Schönbein, it has received support from the work of Boutmy and Chateau[4] who pointed out the power of chromic, sulphuric and permanganic acids to promote passivity, and from the more recent researches of Renard[5], in which it was shown that reducing agents have a tendency to destroy the passivity of iron, while oxydizing agents tend to bring about the passive state.

II.

The behavior of iron in nitric acid solutions varies in the most striking manner with the temperature and strength of solution, and with the molecular condition of the metal. The active metal may be dissolved with evolution of nitrous fumes and the production of a ferric salt, with the evolution of hydrogen and the formation of a ferrous salt, or without the evolution of any gas; the character of the reaction depending upon strength of acid and temperature.[6] In anticipation of similar variations in the transition from the passive to the active state, it was thought best before undertaking the study of the influence of magnetism upon passivity, to make the following preliminary experiments.

1.—*On the behavior of passive iron in cold nitric acid.*

One gram of iron was placed in 8 cc. of nitric acid (1.368) and allowed to stand.

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[1] On the Chemical Behavior of Iron in the Magnetic Field: Am. Jour. Sci., vol. 31, April, 1886.

[2] Experimental Researches of Faraday. Vol. II, p. 237; also Philosophical Magazine, May, 1836.

[3] Faraday; Experimental Researches. Vol. II, p. 244.

[4] Boutmy and Chateau; Cosmos, XIX, p. 117.

[5] Renard; Comptes Rendus. Vol. 79, No. 5.

[6] Ordway; American Journal of Science. II Vol. XL, p. 316.

The metal was apparently perfectly passive, and maintained that appearance throughout the experiment. The temperature of the solution was 20° C. Upon standing, the acid began to show signs that the passivity was not complete, at the end of an hour the amount of iron in solution being sufficient to color the acid unmistakably. Repetitions of the experiment always with the same result led to the conclusion that at least in the case of finely-divided "iron by alcohol" in strong acid, Ordway's third reaction (the solution of the iron without the evolution of gas) was always going on.

2.—*On the destruction of passivity by heat.*

A test-tube containing passive iron in the strong nitric acid was placed in a water bath, and gradually heated. Rise of temperature was found to increase the rapidity of the reaction without evolution of gas. This reaction was gradually supplanted by the second reaction described by Ordway—with elimination of hydrogen—effervescence becoming very evident at 60° C. Under these conditions the metal certainly could not be considered as "passive" in the strict sense of the word, and yet the reaction differed entirely from that of strong acid upon active iron. At this temperature the concentrated acid acts upon "passive" iron in a way similar to that in which very dilute acid attacks the active metal. The transition between these two reactions was not sharply marked. Further heating increased the effervescence, until within the neighborhood of 80° nitrous fumes began to be evolved. The reaction was still far from reaching that which such acid is capable of exerting upon active iron, but the condition of the solution became more and more unstable, and a slight rise of temperature sufficed to render the iron subject to the full effect of the acid. This final and complete loss of passivity was very sharply marked by the beginning of a reaction of fairly explosive violence. Repetitions of this experiment showed that the temperature at which these successive changes occur depends upon a variety of circumstances. It was found to vary with the time the iron had been exposed to the acid, the strength of the acid, and the character of the iron. Even the presence of small quantities of the salts of iron produced by these reactions was found to influence in a marked degree the temperature at which in a subsequent trial the metal became active.

3.—*The influence of time.*

The influence of the time of exposure upon the temperature of loss of passivity was first noticed during the experiments just described. A test-tube containing passive iron in nitric acid had been allowed to stand for some time before being placed in the water bath. Instead of retaining its passivity to a temperature of nearly 90°, this specimen became active at a much lower temperature. Repeated trials showed that continued exposure always lowered the temperature of loss of passivity. For the purpose of determining the extent of this variation, other conditions were kept as nearly uniform as possible, and the iron was exposed for different intervals of time to the acid before the destruction of passivity. The control of conditions but imperfectly understood was exceedingly difficult, and the results showed irregularities which would doubtless disappear were the time the only source of variation. The series given in the following table is thought, however, to indicate with a fair degree of accuracy the influence of the time of exposure upon the temperature of loss of passivity. The time given in the table is that which elapsed between placing the iron in the acid and its change to the active condition. It will be seen that the temperature of transition diminishes as the time of exposure increases.

TABLE, showing influence of the duration of exposure to the acid upon the temperature at which iron becomes active in HNO_3; sp. gr. 1.368.

Number.	Duration of exposure.	Temperature of transition.
		Deg. C.
1	0m., 45s.	89.4
2	1m., 2s.	84.2
3	4m., 25s.	79.3
4	6m., 25s.	78.7
5	9m., 30s.	78.3
6	13m., 50s.	71.5
7	25m., 30s.	70.8

4. *On the influence of the presence of Iron-salts in the solution.*

The presence of even a small amount of the final products of the action of nitric acid upon iron was found to lower the temperature of transition to the active state to a marked extent. In order to obtain consistent results, it was necessary to clean the test-tubes in which the reaction was to take place, and the thermometer, by boiling in sulphuric acid. The failure to thoroughly cleanse the latter repeatedly reduced the temperature many degrees (in one instance to 60°), and in a test-tube from which the products of a former reaction had not been entirely removed, it was often impossible to render iron passive, even at 20°.

5. *On the influence of the strength of acid.*

A much more obvious cause of variation in the temperature of transition than those already alluded to, lies in the different strengths of acid in which the iron is submerged. A set of experiments upon this variation gave the following results:

TABLE, showing temperature of transition from the passive to the active state in acid of different degrees of concentration.

Sp. gr. of acid	Temperature of transition
1.368	89.5°
1.354	82.3
1.306	69.6
1.130	23

The time of exposure to the acid was in each case about 40 seconds. This determination agrees well with that noted by Schönbein for iron wire in nitric acid of sp. gr. 1.35. He found the change to occur at 75°.

III.

In all these experiments, the method pursued had been very simple. The powdered iron was placed in the bottom of a perfectly clean and dry test-tube, and the acid, having been measured out into a beaker, was poured upon it. The test-tube was placed in the water-bath, a thermometer was inserted in the acid, and the transition temperature, always indicated by an explosion of such violence as to expel the greater portion of the contents from the tube, was noted. In order to protect the observer from the explosion, an inverted glass funnel was set over the whole, part of the thermometer projecting beyond the tube of the funnel. Figure 1 shows the arrangement of this apparatus.

In carrying on similar experiments in the field of an electro-magnet, the complete protection of the instrument from the acid fumes generated by the reaction, was necessary. This was accomplished by the apparatus shown in figure 2, in which all the fumes generated were carried away. The test-tube holding the iron and acid for the reaction was placed in a slightly larger tube between the pole pieces of a large electro-magnet. Into the mouth of the larger tube was fitted a thermometer by means of a rubber cork; a long and narrow tube inserted just below the mouth of this outer tube, afforded an exit for the gaseous products of the reaction. The escaping gases were caught over a pneumatic trough.

The electro-magnet was a large one, designed with special reference to this work. The diameter of each of the cores was 55 mm. and their length 380 mm. The pole pieces of this magnet were so fashioned that the tube containing the iron and acid could be brought into a field of high intensity, (about 20,000 H.)

FIG. 1.

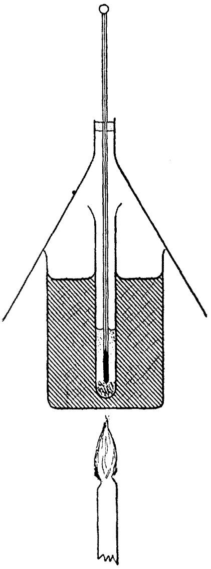
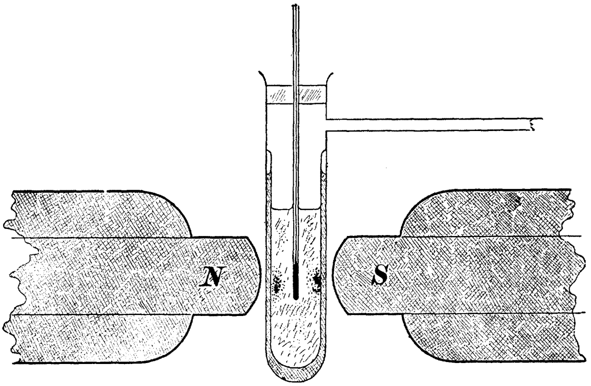


FIG. 2.



The magnet was actuated by means of a battery of grenet cells, and a rheostat of simple construction made it possible to reduce the strength of current at will. This instrument consisted of a fine platinum wire, .03 mm. diameter and 65 cm. long, which was stretched in a glass tube of 5 mm. diameter. To the lower end of the glass tube was fastened one of soft india-rubber, rather more than a meter in length, to the free end of which a glass funnel was attached. The glass tube having been fastened vertically to an iron standard, and the funnel being supported in an adjustable ring attached to the latter, the funnel was filled with mercury, which thus entered the glass tube containing the platinum wire. By raising and lowering the funnel, this mercury column could be made to occupy any desired portion of the tube. That part of the platinum wire not immersed in mercury, constituted the resistance wire of the rheostat, and this resistance could be given any desired value up to that offered by the entire wire. To prevent the heating of the resistance wire, the tube above the mercury was filled with distilled water, the top of the tube being enlarged to receive the water when expelled by the rising mercury. This rheostat is shown in figure 3.

The strength of field was estimated by observing the swing of a delicately suspended galvanometer needle induced by the withdrawal of a small coil of known area from the field, and by comparing this deflection with that produced upon the same needle by a Weber's "earth inductor."

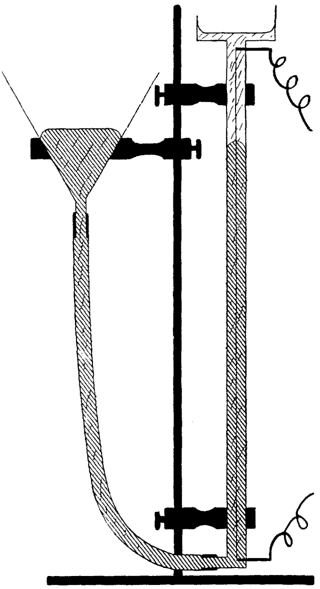


FIG. 3.

With this apparatus the influence of magnetism upon the passivity of iron was studied under various circumstances and conditions. It was found very difficult, even with the knowledge of the causes of the variation in the temperature of transition gained from the preliminary experiments, to obtain entirely concordant results, but we succeeded nevertheless in establishing a number of interesting facts concerning the action of the magnet. The following paragraphs descriptive of the more interesting results obtained with the magnet are taken directly from the rough notes made while the investigation was in progress.

(*a*) 8cc. HNO_3 sp. gr. 1.368 acting upon 1 grain of iron in the magnetic field. The tube containing the iron and acid was immersed in water which up to the beginning of the experiment had been boiling, but from which the flame had just been removed. The strength of the field, which was insufficient to destroy passivity at the temperature of the room (20°), was not measured. Effervescence began at once, and increased until the thermometer indicated 51°, when the explosion characteristic of the loss of passivity occurred, blowing most of the liquid from the tube. The remainder became quiescent again, but when touched with the thermometer bulb its explosive activity returned. The reaction differed apparently in its nature from that taking place out of the field. The products of the reaction, when poured from the tube, left the tube and the thermometer bulb clean, whereas after the ordinary reaction they were thickly coated with a black residue which could not be washed off and the complete removal of which necessitated long boiling in acid.

(*b*) A repetition of experiment (*a*), with the magnet not acting. The thermometer rose steadily to 89°, when the transition to the active state took place.

(*c*) Conditions those of experiment (*a*). Temperature of transition again 51°. We noticed that passivity was not lost throughout the mass of iron at once, but began at a single point on the side of the tube, whence streams of gas were evolved, while the rest of the iron remained passive.

From this as a center the action spread until the entire mass became involved. The temperature noted was that at which activity had become general.

(*d*) Conditions those of experiment (*a*), excepting that the magnet was inactive until the temperature of the solution reached 60°, when the circuit was closed. Passivity was destroyed at once.

(*e*) Conditions those of experiment (*a*), excepting that the circuit was made and broken at every degree from 40° upward by tapping a key. But little effect could be noticed until in the neighborhood of 60°. Each tap was followed by momentary effervescence and by a sudden rise of the thermometer, which were more and more marked as the solution became hotter. Complete and permanent activity, such, namely, as was capable of maintaining itself without the continued action of the magnet, did not occur until a temperature of 87.5° was reached.

(*f*) A repetition of experiment (*a*), but with less current, [.28, as much as indicated by a tangent galvanometer in the circuit.] The magnet was in function throughout the experiment. The transition temperature was 84.5°.

(*g*) The acid and iron were placed in a bath at 20°, and brought into a much stronger field than that employed in experiment (*a*). [Strength of field, estimated by the method described in a former paragraph, was about 20,000 H.] Loss of passivity in this field occurred instantly upon closing the circuit.

(*h*) The acid was diluted with one-half its bulk of water; and the iron having been introduced under the protection of a strip of platinum foil remained passive when the latter was withdrawn. The temperature of the acid was 23°. The iron lost its passivity instantly in a field of very moderate intensity, and regained it only when removed from the neighborhood of the magnet. The very slight residual magnetism of the electro-magnet was found to be sufficient to destroy passivity in this dilute acid, the action recurring violently whenever the tube was brought between the poles of the magnet, even when the circuit was open. Upon repeating this experiment with somewhat stronger acid we found the strength of field requisite to the destruction of passivity much greater with three parts of acid and one of water; the iron remained passive under the residual magnetism of the magnet, and even in the field produced by the current last employed. When the current was somewhat further increased the iron became active.

The tangent galvanometer when the transition took place, indicated .16 of the current which in experiment (*a*) had been necessary to destroy the passivity in concentrated acid at 51°. And the field was certainly of but little more than half the strength of that under which, in experiment (*f*), iron had maintained its passivity in the stronger acid to 84.5°.

In four parts of acid and one of water, at a temperature of 23.3°, the iron remained passive until the current strength had reached .23 of that used in experiment (*a*).

(*i*) To determine in what strength of acid iron would become active at these temperatures, without the influence of magnetism, or at least in the earth's field, the usual quantity of iron was placed in concentrated acid and the acid rapidly diluted with water and with such small amounts of snow as were necessary to keep the mixture in the neighborhood of 23°. Dilution was continued until the iron had become active. The transition was much less clearly marked than at high temperature or within the magnetic field, but repeated trials showed that the amount of water to be added to 10 parts of acid in order to destroy passivity was about 13.

(*j*) To 20 cc. of concentrated acid at 0° containing passive iron, water was added, with snow in quantities sufficient to prevent any marked rise of temperature. The addition of 172.3 cc. of water and snow did not produce any noticeable reaction. When placed in the field of the electro-magnet [strength about 20,000 H], effervescence began at once, and a dark-green solution of higher density than the acid was formed. The color soon disappeared and a brown precipitate showed itself, which was dark colored and highly magnetic.

By repetition of the experiment outside of the field, it was found that a trace of color could be detected when the acid had been diluted to $\frac{10}{47}$, (subsequent trials changed this ratio to $\frac{1}{8}$,) and that the first evolution of gas could be noticed when the strength of the acid had been further reduced to $\frac{1}{13}$. Further dilution to $\frac{10}{261}$ produced no further changes, nor did the evolution of gas at any time approach that produced in the magnetic field at this temperature.

It appears from the foregoing experiments, that the action upon the passivity of iron in nitric acid consists in lowering the temperature of transition to the active state, and that the intensity of the magnetic field necessary to convert passive into active iron at a given temperature increases rapidly with the concentration of the acid. The influence of magnetism upon the passivity of iron in other acids must be determined by other experiments. The establishment of a satisfactory theory of the influence of magnetism upon passivity will demand not only a much more complete acquaintance with the phenomena touched upon in this paper, but a wider knowledge than we now possess of the subject of chemical action in the magnetic field.